

*DoD/IC/NSGI Motion Imagery Standards Board*

**Recommended Practice 0402:  
Infrared Motion Imagery Capture**

**MISB RP 0402**

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## Introduction

This recommended practice defines five infrared image signal structures and parallel interface for IR motion imagery. All of the image structures are based on a progressive scan operating at 50Hz or 60 Hz frame frequency at various bit depth from 8 to 16 bits.

The supported image signal structures operating at 60Hz frame rate are:

- 640 pixels x 480 lines
- 720 pixels x 480 lines
- 1280 pixels x 720lines

and at 50 Hz frame rate image structures supported are:

- 720 pixels x 576 lines
- 1280 pixels x 720 lines

The IR image signal structure defined in this document defines structure of the interface signal, its synchronization, as it appears on the parallel output interface. It should be mentioned that parallel output interface is rarely used as a transmission of the signal over longer distances however its usefulness is in defined connectivity of various processing blocks within or between equipment.

The IR image signal structures are based on two basis clocks, one based on 27MHz (27.027MHz) sampling and another on 74.25MHz sampling. These clocks are direct derivatives of clocks that are used in Standard and High-Definition television, so these IR systems may be compatible with the commercial television equipment.

This recommended practice establishes the location of the digital dynamic range for various bit word depths (8 to 16 bits) so the resulting signal from a lower bit-depth interface may operate in the same bit range as the signal from a high bit-depth interface. This is achieved by establishing a common lowest reference ("black level") and highest level (100% level) for all scanned images regardless of their bit digitization.

This document complements another document of the DoD/IC/NSGI Motion Imagery Standards Board, Standard 0403. Standard 0403 covers Serial Interface for the IR systems covered in this document and the parallel output of this interface is directly compatible to the input interface of the Serial Interface document, Standard 0403.



# Parallel interface for Infrared Motion Imagery

## 1 Scope

This recommended practice defines a synchronous parallel interface for infrared Motion imagery formats supporting bit word depth from 8-bits up to 16-bits at clock frequency 27.027MHz, 27MHz or 74.25MHz. All of the indicated image structures shall be generated as progressively scanned signal.

Sampled infrared image sample structures (raster) with associated clocking frequency may attain formats shown in Table 1. Because of existence of various bit depths of transmitted words, all synchronizing signals shall be detected by reference only to the eight most significant bits. The remaining bits are discarded.

**Table 1 – Infrared motion image structures**

IR Sys-tem	Infrared active Image lattice	Frame rate	Number of lines per frame	Number of total words per each line	Number of active samples/words of an IR image per each line	Pixel sampling clock	IR signal bit rate on the interface at 16 bit depth
1	640 x 480	60Hz	525	858	640	27.027MHz	432.432Mb/s
2	720 x 480	60Hz	525	858	720	27.027MHz	432.432Mb/s
3	720 x 576	50Hz	625	864	720	27MHz	432Mb/s
4	1280 x 720	60Hz	750	1650	1280	74.25MHz	1.188Gb/s
5	1280 x 720	50Hz	750	1980	1280	74.25MHz	1.188Gb/s

The bits of the digital code words that describe the infrared signal shall be transmitted in a parallel arrangement using sixteen conductor pairs in form of individual digital words with appropriate bit depth. Accordingly, total bits rate on the interface is as indicated in this section. A seventeen conductor pair carries a clock signal at associated clock frequency

The interface allows the transmission of appropriate ancillary signals that may be multiplexed into the data stream during infrared signal blanking

## 2 Normative References

The following standards contain provisions, which through reference in this text constitute provisions of this recommended practice. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this recommended practice are encouraged to investigate the possibility of applying the most recent edition of the standards indicated below.

No Normative References are specified for implementation of this recommended practice.

### 3 General Considerations

#### 3.1 Recommended Practice Compliance Requirement

The specification of a system claiming compliance with this recommended practice shall state:

- which of IR systems/structures of table 1 are implemented
- what signal processing is implemented (transfer function, filtering, or other process)
- whether the digital representation employs uniformly quantized (linear) PCM
- number of bits on the parallel interface

Note: It is not necessary to support all structures and formats and/or 16 bit bus structure for an implementation to be compliant with this recommended practice.

#### 3.2 Sampling frequency tolerance

The Interface sampling frequency shall be maintained to a tolerance of  $\pm 10$  ppm

### 4 Raster Structure

#### 4.1 Sample sequence and line numbering

Pixel representation at the interface of the IR image shall be presented from left to right and in lines from top to bottom. Lines are numbered in time sequence according to the raster structure described in this section and shown in figures 1a thru 1c and figures 2a thru 2c.

#### 4.2 Line sequence in progressive scanning

A progressive frame shall comprise of the indicated total number of lines per frame in order from top to bottom. Each line at the interface shall be of equal duration determined by the interface sampling frequency and samples per total line (S/TL) for a given IR system. The time difference between any two adjacent sample instants is called the reference clock interval T.

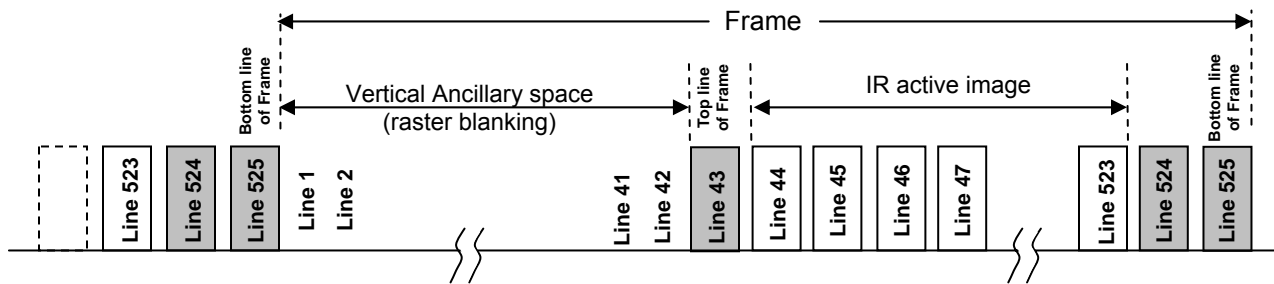
#### 4.3 Vertical raster structure (vertical blanking)

Raster structure in vertical direction and vertical Ancillary space for IR systems 1 thru 5 shall be as indicated in Table 2 and figure 1a thru 1c.

**Table 2 – Vertical Raster Structure for IR system 1 through 5**

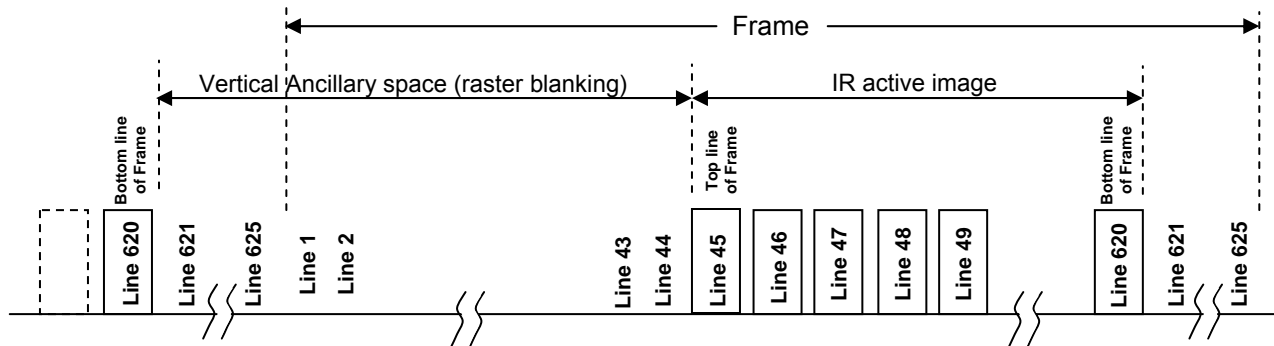
IR System	Active Image Raster	Number of lines per frame	Vertical blanking lines #	Blank (empty) lines #	Active Image lines #
1	640 x 480	525	1 thru 42 incl.	43; 524; 525	44 thru 523 incl.
2	720 x 480	525	1 thru 42 incl.		
3	720 x 576	625	1 thru 44 incl. 621 thru 625 incl.	NA	45 thru 620 incl.
4	1280 x 720	750	1 thru 25 incl.	NA	26 thru 745 incl.
5			746 thru 750 incl.	NA	

Note: Content of Blank (empty) lines shall be set to a level corresponding to 0% signal level as related to a relevant bit code as shown in Table 7. (E.g. for an 8-bit A/D conversion, the level is set to 10h)



**Figure 1a - Vertical blanking for IR system 1 and 2 (525 lines system)**

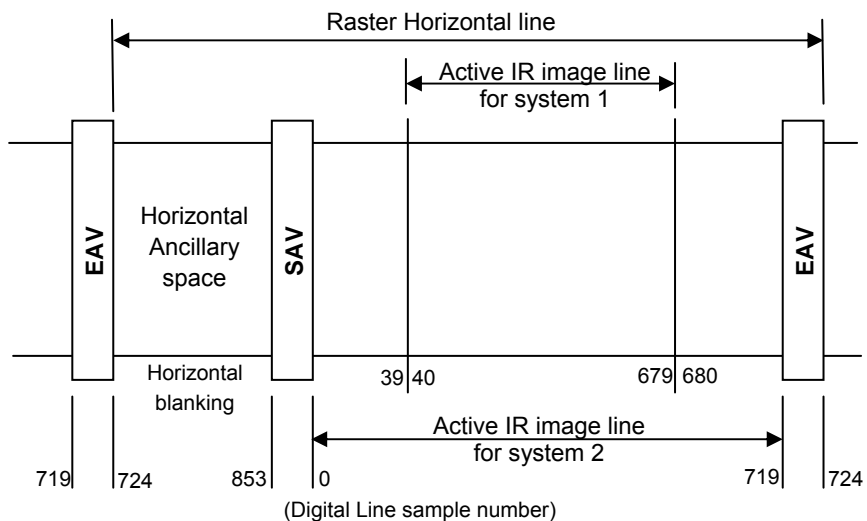
Note: Lines shown in dark do not contain image data and the code is set to 10h



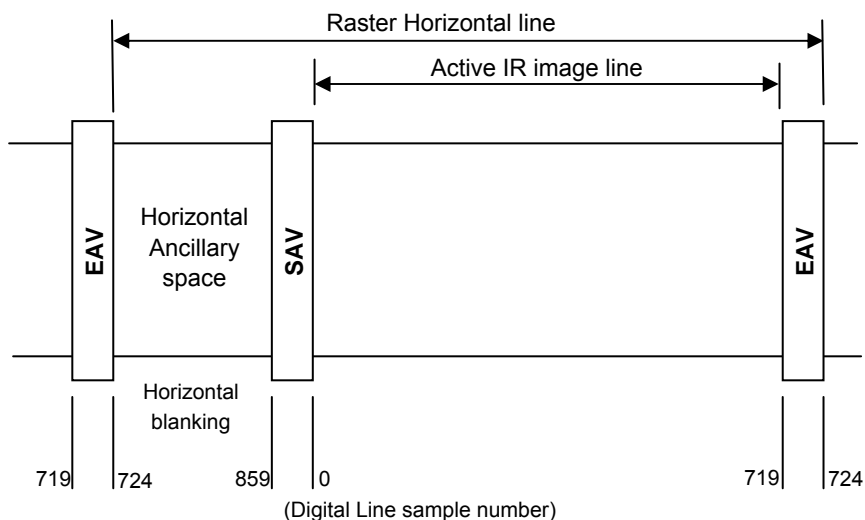
**Figure 1b – Vertical blanking for IR system 3 (625 lines system)**

4	1280x720	1650	1280	NA	362
5	1280x720	1980	1280	NA	692

Note: Content of Blank (empty) words in a line shall be set to a level corresponding to 0% signal level as related to a relevant bit code as shown in Table 7. (E.g. for an 8-bit A/D conversion, the level is set to 10h)



**Figure 2a – Raster horizontal line structure for IR system 1 and 2 (640x480 and 720x480)**



**Figure 2b - Raster horizontal line structure for IR system 3 (720x576)**





for IR Systems 1, 2 and 3      4 : 3  
for IR Systems 4 and 5      16 : 9

## 5 Synchronizing words (timing and reference signals)

### 5.1 Synchronizing words and protection codes

The parallel interface is a synchronous interface and as such shall carry the synchronizing words (timing and reference signals) in a specific pattern along the parallel data stream.

The position of the timing reference signals (SAV – Start of active video, EAV – End of Active Video) with respect to horizontal blanking data stream is shown in figure 2a thru 2c. It is implicit that the timing reference signals are contiguous with the IR image data when present, and continue through the vertical blanking interval. Each timing reference signal consists of a four-word sequence in the following format:

- 8 bit      FFh – 00h – 00h - XYZh
- 10 bit    3FFh - 000h - 000h – XYZh
- 12bit    FFF – 000f – 000h – XYZh
- 14 bit    3FFF – 0000h – 0000h – XYZ0h
- 16 bit    FFFF – 0000h – 0000h – XYZ0h

Due to existence of various bit depth equipment (see table 4 and 5), for detection purposes all values in the relevant protected ranges must be considered equivalent to 00h and FFh. The first three words of the synchronizing word are a fixed preamble. The fourth XYZh word shall contain information defining state of vertical blanking and horizontal blanking.

Assignment of bits within the fourth word is shown in table 4. An SAV sequence shall be identified by H = 0, and EAV sequence is identified by H = 1. In progressive system F bit shall be always set to 0 and V bit changes its state during vertical blanking on the first line following the "Bottom Line of a frame" as shown in figure 1a thru 1c for all IR system. P0, P1, P2, and P3 (parity bits) have states dependent on states of bits F, V, and H according to table 5.

Because of existence of various bit depths of transmitted words, all synchronizing signals shall be detected only to the eight most significant bits. The remaining lower order bits are discarded.

**Table 5 - Timing Reference codes and Protection bits for SAV and EAV  
for 8 to 16 bit words**

Bit number		$b_{(n-1)}$ (MSB)	$b_{(n-2)}$	$b_{(n-3)}$	$B_{(n-4)}$	$b_{(n-5)}$	$b_{(n-6)}$	$b_{(n-7)}$	$b_{(n-8)}$
Word									
<b>0</b>		1	1	1	1	1	1	1	1
<b>1</b>		0	0	0	0	0	0	0	0
<b>2</b>		0	0	0	0	0	0	0	0

<b>3</b>		<b>1</b> (fixed)	<b>F</b>	<b>V</b>	<b>H</b>	<b>P3</b>	<b>P2</b>	<b>P1</b>	<b>P0</b>
		1	0	0	0	0	0	0	0
		1	0	0	1	1	1	0	1
		1	0	1	0	1	0	1	1
		1	0	1	1	0	1	1	0

Bit number continue	$b_{(n-9)}$	$b_{(n-10)}$	$b_{(n-11)}$	$b_{(n-12)}$	$b_{(n-13)}$	$b_{(n-14)}$	$b_{(n-15)}$	$b_{(n-16)}$ (LSB)
0	1	1	1	1	1	1	1	1
1	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0

3	1 (fixed)	F	V	H	P3	P2	P1	P0
	1	0	0	0	0	0	0	0
	1	0	0	0	0	0	0	0
	1	0	0	0	0	0	0	0
	1	0	0	0	0	0	0	0

Where:  $8 \leq n \leq 16$  for words 1 thru 3

H = 1 for EAV

H = 0 for SAV

V = 1 during active raster where IR image maybe located

V = 0 during vertical blanking of the IR signal raster

An error detection and correction states in the received timing reference signal is shown in Annex B

## 5.2 Protected word range

Because of the existence of multiple bit bus equipment, for detection purposes all values in the protected word ranges shown in table 6 must be considered equivalent to LSB and MSB in a given bit range

**Table 6 – Protected words range in IR system 1 thru 5**

Bit range	8 bit (hex)	10 bit (hex)	12 bit (hex)	14 bit (hex)	16 bit (hex)
MSB	FF	3FF	FFF	3FFF	FFFF
Protected words range	FF	3FC ~ 3FF	FF0 ~ FFF	3FC0 ~ 3FFF	FF00 ~ FFFF
Image data	NA	NA	NA	NA	NA
Protected words range	00	000 ~ 003	000 ~ 00F	0000 ~ 003F	0000 ~ 00FF
LSB	00	000	000	0000	0000

## 6 Ancillary data space

Ancillary data may be inserted in any portion of the data stream not occupied by timing reference signals or IR image data (including empty words) as shown in figures 1 and 2.

Two categories of ancillary data, HANC and VANC, are defined for different portions of the data stream.

Note: The three-word header used to identify ancillary data is the same for HANC and VANC. HANC and VANC data packet format shall be determined by the SMPTE 291M.

### 6.1 Horizontal ancillary data (HANC data)

HANC data are permitted in all horizontal intervals, including vertical blanking interval, but not in the active portion of lines. Each packet of HANC data is preceded by the three-word ancillary data header:

000h 3FFh 3FFh

Note: Shown ancillary data header is for 10 bit system. For systems with different number of bits, the header shall be changed accordingly to the selected bit system.

Multiple HANC packets of ancillary data may occur multiple times during each horizontal blanking period according to rules set forward in SMPTE 291M. All rules as defined in section 5 on protected words must be observed by the inserted ancillary data packet header.

## 6.2 Vertical ancillary data (VANC data)

VANC data are permitted in all horizontal lines present during the vertical blanking interval for each IR system. Each packet of VANC data is preceded by the three-word ancillary data header:

000h 3FFh 3FFh

Note: Shown ancillary data header is for 10 bit system. For systems with different number of bits, the header shall be changed accordingly to the selected bit system.

Multiple ancillary data VANC packets may occur multiple times during each horizontal line present in the vertical blanking interval according to rules set forward in SMPTE 291M. All rules as defined in section 5 on protected words must be observed by the inserted ancillary data packet header.

## 7 Image coding characteristic

### 7.1 Quantization

The IR image shall be uniformly-quantized PCM binary encoded data stream at 8-bits or 10-bits or 12bits or 14-bits or 16-bits bits per sample. The scan of the IR image shall be of a progressive type, frame and line repetitive. Sampling frequency shown in table 7 is nominal for given IR system.

### 7.2 Coding parameters

**Table 7 – Coding parameters for IR image**

Parameters	IR image frame frequency 60Hz			IR image frame frequency 50Hz	
IR system	1	2	4	3	5
Image Active Samples Line(H) x (Line (V)	640 x 480	720 x 480	1280 x 720	720 x 576	1280 x 720
Number of Samples in a Line	858	858	1650	864	1980
Sampling frequency	27.027MHz	27.027MHz	74.25MHz	27MHz	74.25MHz
Sampling Structure	Progressive scan, frame and line repetitive				
Coding Format	Uniformly quantized PCM at 8 or 10 or 12 or 14 or 16 bits				
Filter Template	A	A	B	A	B

Note: Filter template for different IR systems is shown in Annex A.

## 8 Coding bit range assignment

The range of the binary coding shall be as shown in table 8 according to its selected bit range.

Note: The range is selected such way that 0% signal level is constant and independent of selected number of bits for sampling.

**Table 8 - Digital range assignment for different word sizes on a parallel signal bus**

Bit range	8-bit (hex)	10-bit (hex)	12-bit (hex)	14-bit (hex)	16-bit (hex)
Most Significant	FF (255)	3FF (1023)	FFF (4095)	3FFF (16383)	FFFF (65535)
Protected words range	FF (255)	3FC~3FF (1020~1023)	FF0~FFF (4080~4095)	3FC0~3FFF (16230~16383)	FF00~FFFF (65280~65535)
Overshoot words range	EC~FE (236~254)	3AD~3FB (941~1019)	EB1~FEF (3761~4079)	3AC1~3FBF (15041~16319)	EB01~FEFF (60161~65279)
100% White signal level	EB (235)	3AC (940)	EB0 (3760)	3AC0 (15040)	EB00 (60160)
0% Black signal level	10 (16)	40 (64)	100 (256)	400 (1024)	1000 (4096)
Undershoot words range	01~F (1~15)	04~3F (4~63)	010~0FF (16~255)	40~3FF (64~1023)	100~FFF (256~4095)
Protected words range	00 (0)	000~003 (0~3)	000~00F (0~15)	0000~003F (0~63)	0000~00FF (0~255)
Least Significant	00 (0)	000 (0)	0000 (0)	0000 (0)	0000 (0)

Note: The Protected words ranges shown in table 6 and 8 are necessary to assure proper synchronization of the resulting stream IR image stream.

Note: The Undershoot and Overshoot words provide for a dynamic range needed for potential overload and to satisfy the sampling theorem (Nyquist rule)

## 9 Signal filtering (optional)

Conversions for direct viewing of the digital infrared image from digital to analog domain presume that post-filters which follow D/A conversion process provide for a  $\sin(x)/x$  correction that is complementary to the original  $\sin(x)/x$  filtering of the acquired image during the A/D digital conversion. This is most easily achieved if, in the design process, the pre and post filter is treated as a single unit.

It is recognized that pass-band tolerances for amplitude ripple and group delay are very tight, nevertheless, it is possible to design filters so that the specified characteristics are met in practice, and manufacturers are required to make every effort to assure that each filter meets the given requirements.

IR system 1 thru 5 filter templates for the insertion loss, pass-band loss and group delay are located in an informative Annex A.

## 10 Interface clock and jitter

### 10.1 Clock

One pair of wires on the interface shall convey a clock signal at the sampling frequency, which shall have a positive pulse width of  $(0.5 \pm 0.11) T$  and shown in figure 3.

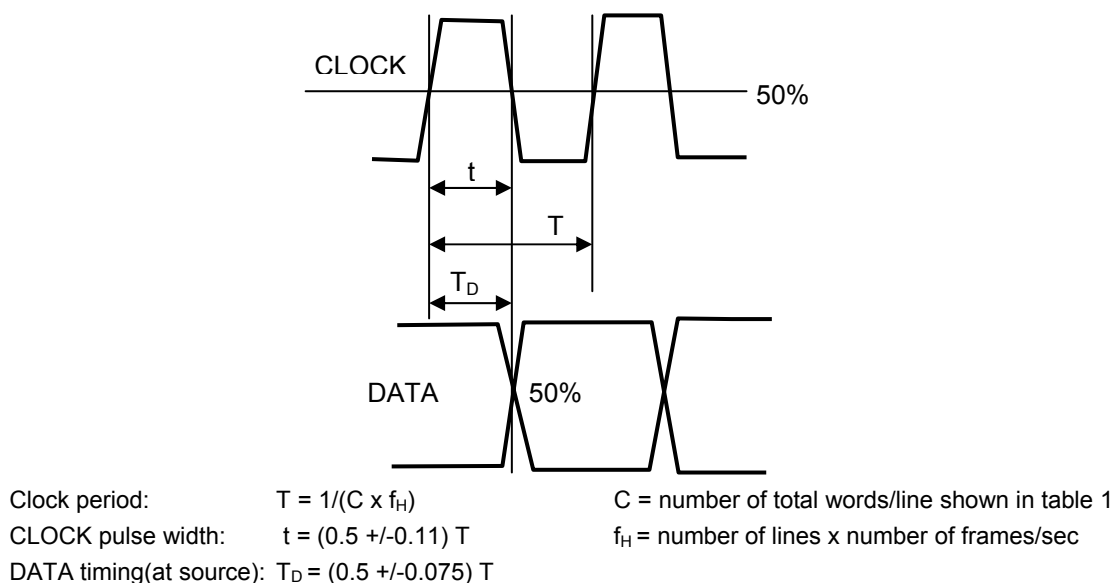
Data signals shall be asserted by the transmitter at a time interval  $(0.5 \pm 0.075) T$ , denoted  $T_D$ , following the 0-to-1 transition of the clock, according to figure 3.

Data signals "DATA (0-15)" shall be sampled at the receiver by the 0-to-1 transition of the clock.

## 10.2 Clock Jitter

Peak-to-peak jitter between rising edges of the transmitted clock shall be less than  $0.08T$ , measured over a period of one frame.

Note: This jitter specification, while appropriate for an effective parallel interface, may not be suitable for clocking digital-to-analog conversion or parallel-to-serial conversion.



**Figure 4 – Interface clock**

## 11 Bibliography

Standard 0403 - Digital Representation and Source Interface formats for Infrared Motion Imagery mapped into 1280 x 720 format Bit-Serial Digital Interface.

ITU R-BT 1358 – Studio Parameters of 625 and 525 Line Progressive Scan Television Systems.

SMPTE 296M - 1280 × 720 Progressive Image Sample Structure — Analog and Digital Representation and Analog Interface.

SMPTE 291M-1998 - Television - Ancillary Data Packet and Space Formatting.

SMPTE 292M-1998 -Television - Bit-Serial Digital Interface for High-Definition Television Systems.

Uncooled B-Kit Specification and Interface Control Document, Army PM NV- RSTA, 2004.

# Annex A(informative)

## A.1 Filter templates

+0.05

Note: - The value of fs for IR system 1 thru 5 is given in table 6.  
Template A is associated with fs = 27MHz  
Template B is associated with fs = 74.24MHz

0.40 fs

## Annex B

### B.1 Error detection and correction in the timing reference signal (SAV, EAV)

Table B1 Error correction table enables single bit errors in the fourth bytes of EAV and SAV to be corrected. Double errors, and some multiple-bit errors, are detected but not corrected.

The table gives corrected values for bits 8, 7, and 6 where possible. Multiple errors are denoted by an “x”.

**Table B1 – Error Correction Table**

Received bits P3 ~P0	Received bits F, V and H			
	000	001	010	011
0000	000	000	000	x
0001	000	x	x	111
0010	000	x	x	011
0011	x	x	010	x
0100	000	x	x	011
0101	x	001	x	x
0110	x	011	011	011
0111	100	x	x	011
1000	000	x	x	x
1001	x	001	010	x
1010	x	101	010	x
1011	010	x	010	010
1100	x	001	110	x
1101	010	001	x	001
1110	x	x	x	011
1111	x	001	010	x



## Annex C (informative)

### A method for establishment of a reference point (black level) prior digitizing

Any equipment that digitizes an analog image signal should establish a reference point prior signal digitization. A constant reference point enables the most efficient range utilization of the used A/D converter for optimal processing. Additionally if this signal will be switched with signals from other sources, they share a common digital range and therefore a common operating point is required.

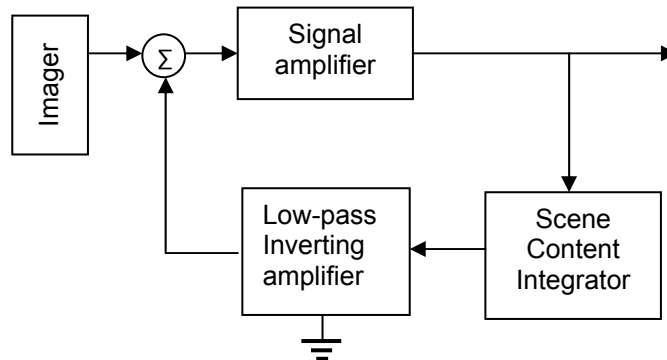
Image information that is provided by an imager consists of many levels that form a picture (image) viewed on a display device. The lowest level corresponds to the low brightness of the scene; intermediate level contains various details of object of interest and finally high signal levels that represent the highest brightness of a given scene. Additionally to those three levels in a given scene is so called specular light formed by a reflection from a shiny object (example is reflection from a highly polished surface of a metal or glass or other). These levels that describe a visible image signal light may be also applicable to IR image, however with some exceptions. In most scenes in the visible light, the background (lowest level) of the scene affects the over all brightness of the scanned image therefore the dynamic range of the image that is viewed on the display device is essentially reduced.

An IR scene imager does not depend on a reflected light because it is registering a wavelength of a spectrum that is invisible to the human eye, but always present. That means a signal from the IR imager is created by sensing energy that is radiated by the object of interest and not by a reflected infrared light. In an IR image the background level of a scene depends on a temperature of the background that is proportional to the background level of the scanned IR image scene.

Interestingly the average DC content of any scene has relatively low energy (DC component) because in the given scene the middle and high level components mostly consist of transitions with peaks and valleys. Therefore if the DC component of the scene background is maintained at a constant point without cutting off the low "brightness" information, the operating point of the image is stabilized and favorable to subsequent digital processing. .

A technique to maintain a constant reference point at the lowest level (background) consists of a scene content integrator and a low-pass inverting amplifier. The resulting signal is fed back to the main amplifier such that the background point is stabilized the lowest (black) level of the scanned IR scene.

A possible block diagram for IR reference point (black level) stabilization



Once a DC reference point has been established, DC coupling is possible throughout the whole processing chain. If AC signal coupling is used, a DC restoration circuit is necessary to recover the DC reference point prior digitizing.